§10. Ion-ion Plasmas in a Caesium Seeded Negative Ion Source

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Powerful and stable beam injection is required for the neutral beam injectors (NBI). In LHD, we have continuously improved the negative ion sources to provide high power beam injections. On the other hand, the production mechanism of hydrogen negative ions (H-) and their transport in the source plasmas are not clear in the case of caesium (Cs) assisted H- enhancement. To obtain more injection power with better stability, it is necessary to investigate the ion-source plasmas near beam extraction region. The H- production and transport mechanism are dependent on the surface, plasma and atomic processes, and thus a system combining some diagnostic devices is required to measure the phenomena in extraction region. The combined system consists of a Langmuir single probe, spatial-resolved cavity ring-down system, millimeter-wave interferometer and optical emission spectrometer. The other authors describe the individual measurement in the diagnostic system, and the observation with the Langmuir probe is described here.

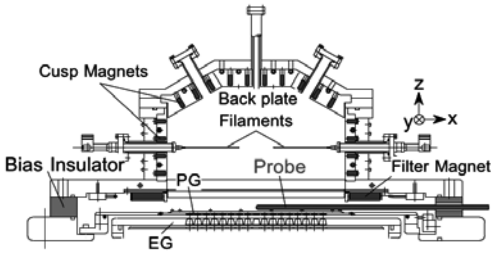

Fig. 1. Cross-sectional view of the negative ion source with the inserted Langmuir single probe near the plasma grid (PG).

Figure 1 shows a cross-sectional view of the negative ion source with the Langmuir probe, which is inserted through the bias plate. The probe tip is situated at 9 mm apart from the PG, and the magnetic strength at the tip position is about 10 mT. The magnetic field is too strong to estimate the electron density and temperature, and thus the electron saturation current is used as a parameter to indicate the electron existence. The electrons emitted from filaments are reduced their energy until reaching the tip position by transporting though a dipole magnetic fields caused by filter magnets and electron deflection magnets imbedded in the extraction grid (EG).

Just after the start to seed Cs, the electron saturation current begins to decrease as shown in Fig. 2(a). In pure hydrogen discharge, a ratio of electron saturation current to ion one is ~10. The decay of the electron saturation current is indicated in Fig. 2(b). The Cs seeding rate is kept at the same value by setting the Cs-oven temperature at 180 °C, and input arc power is set at 72 ± 5 kW. The electron saturation decreases exponentially, and the current saturates at ~3 mA finally.

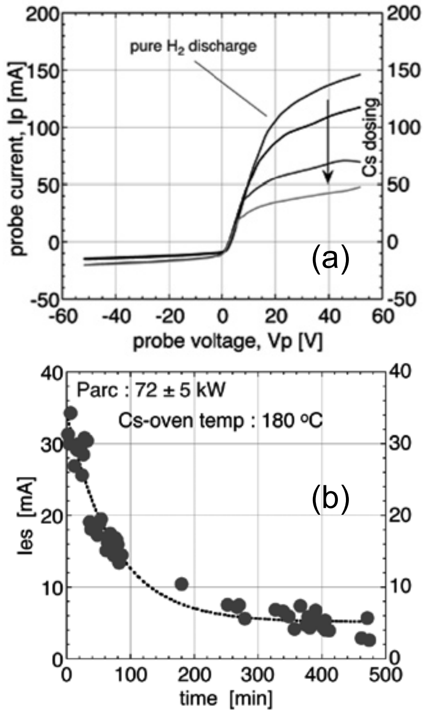

Fig. 2. Change of V-I characteristics after Cs seeding (a), and the decay of the electron saturation current (b).

The absolute values of electron and ion saturation currents approaches very closer by seeding sufficient Cs, and the probe V-I curve becomes symmetry as indicated in Fig. 3. The electron density is considered to be quite low in such plasmas, and the plasma consists only of positive and negative ions. The H- ions are produced on the PG surface lowered the workfunction with adsorption of Cs atoms, and the density of H^- in the extraction region increases. The electrons diffused from filament region, on the other hand, considered to be suppressed to reach the extraction region by thick and strong magnetic fields and the H^- charge density near the PG surface. As the result, ion-ion plasma is produced in the extraction region. The ion-ion plasmas are observed on the conditions of higher operational H_2 pressure and higher bias voltage.

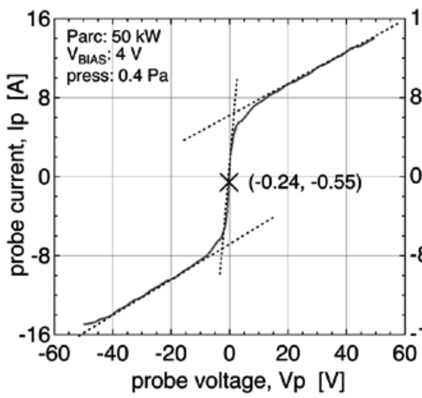

Fig. 3. Prove V-I curve of the hydrogen ion-ion plasma in sufficient Cs seeded condition.